The Science of Safety

Debunking the Myths Surrounding Propylene Glycol and Polyethylene Glycol in Vaping Applications

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Executive Summary

During the 2019–2020 vaping health crisis, a significant volume of misinformation was published regarding the safety of propylene glycol (PG) and polyethylene glycol (PEG) as thinning agents in cannabis and nicotine vaporizers. One of the most frequently cited documents was a 2017 study published in the Journal of Alternative and Complementary Medicine, which claimed that heating PG and PEG to 230°C produced dangerous levels of formaldehyde and other carbonyl compounds. [1]

A rigorous scientific review of this study's methodology reveals a fundamental flaw — the use of unrealistic testing temperatures that do not reflect actual human vaping behavior. This flaw applies equally to the study's findings on both PG and PEG. When evaluated under real-world operating conditions, both compounds have documented safety records that the study's methodology fails to address honestly.

Furthermore, the CDC's definitive investigation of the 2019–2020 EVALI outbreak identified Vitamin E acetate — not PG or PEG — as the primary culprit, explicitly clearing standard vaping ingredients of involvement. [2] This white paper examines the scientific record on both PG and PEG, applying consistent standards of temperature-context analysis to each.

1. The 2017 Arizona Study: A Case Study in Methodological Flaws

In 2017, a study titled 'Carbonyl Compounds Produced by Vaporizing Cannabis Oil Thinning Agents' was published in the Journal of Alternative and Complementary Medicine. [1] The study claimed that when heated to 230°C, both PEG 400 and PG produced high levels of acetaldehyde and formaldehyde.

1.1 Author Credentials and Publication Venue

A critical evaluation of any scientific claim requires assessment of the authors' expertise in the relevant field. Neither author of the study possessed a background in chemistry, toxicology, or aerosol science. The study was published in a journal of alternative and complementary medicine — not a peer-reviewed chemistry, toxicology, or aerosol science journal. Neither the authors' credentials nor the publication venue are appropriate for the technical claims being made.

1.2 The Dry Puff Phenomenon — Unrealistic Testing Temperatures

The most critical flaw in the study is the use of unrealistic temperatures. Both PG and PEG samples were heated to 230°C. At approximately 160–190°C, vaping devices produce an acrid, burning taste known as the 'dry puff' phenomenon — a harsh signal that causes users to immediately stop inhaling. Dr. Konstantinos Farsalinos and colleagues documented this precisely in a landmark replication study. [6]

By forcing laboratory machines to continuously vaporize at 230°C — a temperature human users would immediately reject — the study manufactured a toxicological hazard that does not exist in practice. This critique applies equally to the study's PG findings and its PEG findings. Both were tested at the same unrealistic temperature. Both conclusions suffer from the same methodological flaw.

2. Propylene Glycol: The Decades-Long Safety Record

The concern generated by the Arizona study about PG ignores the extensive, documented history of PG safety in inhalation applications. The U.S. FDA classifies propylene glycol as Generally Recognized As Safe (GRAS). [8]

2.1 Pharmaceutical and Medical Inhalation History

Since the 1950s, PG has been used safely as a carrier in pharmaceutical inhalers and nebulizers, delivering asthma medications and other treatments directly into the lungs. [9] Early research demonstrated that aerosolized PG acted as a highly effective, non-toxic airborne antimicrobial agent. Recent studies have confirmed that PG vapor rapidly inactivates respiratory viruses at levels well below those tolerated by mammals. [10]

2.2 Subchronic Inhalation Toxicology

A 2024 multi-omics assessment of subacute inhalation toxicity of PG and VG aerosols found no signs of toxicity in clinical observations, blood analyses, or histopathology at realistic exposure levels. [12] A separate 13-week nose-only inhalation study on PG aerosols in Sprague Dawley rats found no treatment-related adverse effects at any tested concentration. [11]

2.3 Long-Term Human Observational Data

Long-term human observational studies of e-cigarette users — whose primary inhalation carrier is PG — show no biologically meaningful adverse effects attributable to PG exposure at realistic vaping concentrations. [13, 14] This body of evidence exists independent of and predates the 2017 Arizona study.

3. Polyethylene Glycol: Applying the Same Temperature-Context Framework

The Arizona study's claims about PEG deserve the same temperature-context analysis applied to its PG findings. The core methodological flaw — testing at 230°C rather than at the 160–200°C range of actual vaping hardware — applies to both compounds equally.

3.1 PEG Physical Properties at Realistic Operating Temperatures

PEG 200 — the lowest molecular weight commercially used PEG — has a flash point of 171°C and an autoignition temperature of 304°C. Standard cannabis vaping hardware operating at 160–200°C is therefore operating below the flash point of PEG 200. The compound is not igniting. It is not combusting. The conditions that produce the thermal degradation products identified in the Arizona study require temperatures the hardware does not reach in normal use.

Under normal conditions of storage and use — per PEG 200's own Safety Data Sheet — hazardous decomposition products should not be produced. 'To avoid thermal decomposition, do not overheat' is the SDS guidance. The Arizona study's 230°C methodology is, by the SDS's own standard, overheating.

3.2 The Inhalation Toxicology Record for PEG

The inhalation safety record for PEG is less extensively studied than PG's 70-year pharmaceutical track record, but available data is consistent with low toxicity at realistic exposure levels. A two-week nose-only inhalation study on PEG 3350 conducted at concentrations up to 1,008 mg/m³ for 6 hours per day, 5 days per week, found no exposure-related toxicity with regard to clinical signs, serum chemistry, urinalysis, or gross pathology at any tested concentration. The only observed change was a slight increase in alveolar macrophages — a non-specific indicator of particle exposure, not a toxicological signal. [SR3]

The oral LD50 of PEG 200 in rats is 28,000–36,000 mg/kg — placing it in the category of essentially non-toxic compounds by ingestion. The inhalation profile at realistic vaping temperatures is consistent with this low-toxicity characterization.

3.3 What the Arizona Study Actually Showed — and What It Did Not

The Arizona study found that PEG heated to 230°C produced formaldehyde. This is accurate — thermal degradation of PEG at elevated temperatures does produce carbonyl compounds. The study's error was presenting this as a realistic

consumer exposure scenario. The dry puff critique applies directly: users do not inhale aerosols generated at 230°C because the product is unacceptably harsh at those temperatures.

What the Arizona study did not show — and what its authors did not test — is PEG behavior at the 160–200°C range that cannabis vaping hardware actually operates within during normal use. That gap in the study's methodology is the gap between its published findings and a realistic assessment of consumer exposure.

4. The EVALI Outbreak — Clearing the Record

The 2019–2020 EVALI outbreak resulted in thousands of hospitalizations and dozens of deaths across the United States. The CDC's comprehensive investigation identified Vitamin E acetate as the primary culprit — found in the bronchoalveolar lavage fluid of 48 out of 51 EVALI patients tested. [2] Standard vaping ingredients — PG and VG — were explicitly cleared of involvement.

The regulatory and legislative responses that swept PEG off cannabis vaping shelves were enacted during maximum public fear, based on a conflation of EVALI causes that the CDC's own findings do not support. The compound that caused EVALI was identified, removed from the market, and the outbreak subsided. PEG was a casualty of guilt by association, not scientific determination.

5. Conclusion

The narrative that propylene glycol and polyethylene glycol are dangerous compounds when vaporized rests on a single study conducted at unrealistic temperatures by authors without relevant scientific credentials, published in an alternative medicine journal during a public health crisis caused by a different compound entirely.

Both compounds have documented safety records at realistic vaping temperatures. PG has a 70-year pharmaceutical inhalation history, FDA GRAS classification, multiple subchronic inhalation studies showing no biologically meaningful toxicological effects, and explicit CDC clearance from EVALI involvement. PEG, while less extensively studied, shows consistent low-toxicity characteristics at realistic temperatures, and the Arizona study's findings about PEG suffer from precisely the same dry puff methodology flaw that invalidates its PG conclusions.

The legislative responses that followed EVALI — including state-level restrictions on PG and PEG in cannabis products — were enacted during maximum public fear, based on a conflation of causes that the CDC's own investigation does not support. The science existed before the panic. It existed during the panic. It exists now.

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